6 p downtown

N64-24016
CODE-1
NASA-CR 56647
Cat. 26

OTS PRICE

XEROX $ 1.60 ph

MICROFILM $ ______

Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

STAGE SEPARATION AND PROPELLANT
DISPERSION ORDNANCE SUBSYSTEM

NSP-64-28

TECHNICAL NOTE

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STAGE SEPARATION AND PROPELLANT DISPERSION

ORDNANCE SUBSYSTEM

Prepared by LMSC/LSVP

under

NASA Contracts NAS 8-5600 and NAS 8-9500

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OBJECTIVE

The objective of this report is to document the status of RIFT S-N Stage Ordnance subsystems design at the termination of NASA Contract NAS 8-5600. The ordnance design activity reported herein parallels the evaluation of exploding bridgewire equipment reported in Report IMSC/NSP 63-130, dated 31 December 1963.

1.0 SUMMARY

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The S-N Stage Ordnance system is comprised of two subsystems, (a) the Propellant Dispersion Subsystem and (b), the Separation Subsystem. The system concepts presented herein are consistent with Saturn vehicle design criteria discussed at the Ordnance Splinter Group Meeting held at MSFC December 10-12, 1963. Common Ordnance components are used in each subsystem design. The designs are predicated on the concept that contained detonating fuze (CDF) components are installed in the Nuclear Assembly Building (NAB) where the stage contractor has maximum accessibility, while installation and checkout of the flexible, linear shaped charges (FLSC), retro rockets, and live ordnance is planned for the Vehicle Assembly Building (VAB). Ordnance test programs are recommended for the establishment of reliable component performance in nuclear radiation environments.

Author

2.0 INTRODUCTION

The ordnance subsystem described herein has been designed to use common ordnance components developed under the direction of the R-P&VE-P Laboratory at Marshall Space Flight Center (MSFC) for use on the Saturn V vehicles. Ordnance components listed in MSFC Drawing 40-M002959 (Ref. a) will be qualified to performance criteria consistent with the requirements listed in the RIFT Environmental Specification NSPD 6520002 (Ref. b).

The S-N Stage ordnance subsystem has been revised from the initial concept, as specified in the RIFT Requirements Book (Ref. c), and reflects the subsystem configuration presented at the Ordnance Splinter Group Meeting at MSFC on December 10-12, 1963. See Reference (d). The most recent detail drawings and specifications of common ordnance components have not been received by LMSC and are therefore not discussed in this report.

The design philosophy that governs the ordnance subsystem installation is based upon accessibility during pre-launch operations at the Merritt Island Launch Area (MILA). Since it is highly desirable to install all S-N Stage mounted components at the Nuclear Assembly Building, the only exceptions to this procedure are related to vehicle and personnel safety. Based on the foregoing ground rule, installation of confined detonating fuze components is performed in the Nuclear Assembly Building while flexible linear shaped charges, retro rockets and retro rocket initiators are installed in the Vehicle Assembly Building, following the assembly of the S-N Stage on to the RIFT flight vehicle.

3.0 DESCRIPTION

The Ordnance Subsystem is divided into two subsystems as follows:

a) Propellant Dispersion System which is designed to rupture the tank structure should flight termination be required.

b) Stage Separation System which is designed to separate the RIFT S-N Stage from the Saturn V booster.

3.1 Propellant Dispersion Ordnance

The Propellant Dispersion system shown diagramatically in Figure 1 (NSP 3407-1) is designed to use the common ordnance components developed under the Saturn V Program. The Flight Termination System mounted in the S-N Stage equipment bay receives and processes the electronic signal to trigger two EBW detonators in the Safe and Arming device. The Safe and Arming device is an "in-line/out-of-line" ordnance component that is electrically operated (with a mechanical override capability) to "safe" or "fire" positions. From the Safe and Arm device the contained detonating fuze assemblies are routed to two contained detonating fuze "tees" as shown in Figure 2 (NSP 3406-1). From these ordnance "tees" the pyrotechnic trains are separated into two redundant systems. One pair of ordnance trains interface with the S-II Stage Propellant Dispersion Ordnance System via two ordnance train disconnect units mounted at the stage separation plane. The second pair of ordnance trains are connected to a second pair of contained detonating fuze "tees" that are cross connected redundantly to two sets of flexible linear shaped charge as shown in Figure 3 (NSP 3425-1).

3.1 (continued)

The flexible linear shaped charge is designed and sized to rupture both the propellant tank skin and the internal insulation and thereby enable the propellant to be dispersed.

3.2 Stage Separation Ordnance

The Stage Separation Ordnance subsystem shown schematically in Figure 4 (NSP 3410-1) consists of a redundant system of ordnance pyrotechnic trains, four retro rockets and a flexible linear shaped charge. The design utilizes common ordnance components developed under the Saturn V Program. Each half of the redundant ordnance train consists of an EBW initiator, a pyrotechnic ordnance manifold and matched lengths of contained detonating fuze which connect the retro rockets and the flexible linear shaped charge to the EBW initiator. Four parts of each ordnance manifold are connected to the retro rocket initiators. The fifth port of each ordnance manifold is connected to the flexible linear shaped charge. The sixth port of each ordnance manifold is cross connected to the redundant ordnance manifold and thus completes the redundancy loop. See Figure 5 (NSP 3418-1). The length of the pyrotechnic trains that connects each component to the ordnance manifold will be designed to provide the timing sequence established for stage separation.

Two separation joint designs are shown in Figure 4. Note the effect of the joint design on the estimated size of the explosive charge. While the detail design of the separation joint has not been established, it is evident that tensile and compressive loads carried across the separation plane should each be treated as independent structural requirements.

3.2 (continued)

This design philosophy would result in a separation joint configuration which requires minimum grain loading in the flexible linear shape charge used for stage separation.

4.0 BACKGROUND

4.1 Environmental Effects

Tests carried out at the Los Alamos Scientific Laboratory on organic explosives indicates that outgassing of these materials occurs at a radiation dose level equivalent to that anticipated for ordnance components installed on the S-N Stage. Thus, there is concern that an adequate margin of safety does not exist between the predicted S-N Stage radiation environment and the capability of the organic explosives to perform reliably after exposure to this environment. The scope of data obtained in the radiation exposure tests performed to date has not been sufficient to establish environmental limits and thus further tests and documentation are necessary to identify and confirm the margin of safety for the performance of organic explosives.

The temperature environment of the S-N Stage ordnance subsystems is a function of both the induced aerodynamic heating and the cold soak effect from liquid hydrogen carried in the propellant tank. The common ordnance components being developed under Saturn V vehicle development program will be qualified to thermal environment conditions compatible with conditions specified for the S-N Stage. However, the reliability goals and confidence levels specified for the S-N Stage will require further testing to establish the thresholds of component failure and thus demonstrate the margin of safety.

4.2 General Requirements

System requirements and design ground rules for the S-N Stage Ordnance Subsystem have been formulated in Ordnance Splinter Group Meetings. The following sections present a summation of the ground rules applicable to the RIFT vehicle.

4.2.1 The RIFT S-N Stage Ordnance Subsystem will be designed to use ordnance components developed under a common Saturn V program. See Reference (a).

4.2.2 The S-N Stage contractor is responsible for qualifying components to environmental requirements (i.e., nuclear radiation) that exceed environments common to Saturn V vehicles.

4.2.3 The installation and safety procedures to be used in handling and storing ordnance components will be in accordance with NASA Launch Operations Center (LOC) directives.

4.2.4 Installation and mounting of EBW detonators are required to be accessible from the service arm structure without entering the vehicle.

5.0 FUTURE DEVELOPMENT

An environmental and systems test program for the S-N Stage Ordnance Subsystem is briefly outlined in the following sections. The objective of these tests is to establish confidence in the ordnance subsystem when subjected to the "RIFT peculiar" nuclear environment.

5.1 Proposed Testing

The RIFT Ordnance Test Program described in Reference (d) consists of three phases as follows:

a) Establish Test Requirements

b) Conduct Environmental and Subsystem Tests

c) Perform System Qualification Tests

Since the Stage Separation Ordnance Subsystem will perform its function prior to activation of the nuclear reactor, it is anticipated that no unusual problems will be encountered with the use of organic based explosives in this subsystem. However, the Propellant Dispersion Ordnance Subsystem must maintain its capability to function at any time after activation of the nuclear reactor. In Reference (e) the outgassing of organic explosives was noted when subjected to nuclear radiation environments. Thus, environmental tests conducted under the second phase listed above are specifically directed toward the establishment of confidence in the use of organic explosives in the Propellant Dispersion Ordnance Subsystem.

5.2 Test Objectives

The general objective of the test program outlined above is to establish confidence in the S-N Stage Ordnance Subsystem. Intermediate objectives and data necessary to meet this objective are listed below.

a) Establish explosive grain loading of the flexible linear shape charge to cut S-N Stage structural shapes.

b) Establish performance degradation associated with the "RIFT peculiar" nuclear environment.

5.2 (Continued)

c) Establish the margin of safety in a synergistic environment (vacuum, cryogenic, nuclear) by testing components to conditions beyond RIFT Environmental Requirements (Reference (c)).

d) Establish system and component failure modes to provide data for reliability analyses.

6.0 REFERENCES

a) NASA-MSFC Drawing 40-M-02959, Stage Common EBW Systems Components Requirement Schedule and Procurement Information.

b) NSPD-6520002, RIFT Environmental Specification, dated 15 July 1963.

c) LMSC/A303103, NSP 62-60, RIFT Requirements Book, Vol. I, dated 29 March 1963.

d) LMSC Document, NSP 63-127, Rev. 1, RIFT Presentation for Ordnance Splinter Group, VMDIWG, MSFC, 10-12 December 1963.

e) "The Effects of Nuclear Radiation on Organic Explosives", by L. C. Smith, Los Alamos Scientific Laboratory.